

Against steady-state economics

Underlying Herman Daly's ecological economics is a faith in markets, neo-liberal regulatory tools and theory, and Malthusianism. While Daly criticizes economic growth, he overestimates the ability of regulation to contain a capitalist economy within a 'steady-state'. Cap-and-trade is his main tool to regulate a steady-state economy, even though that tool emerged from neo-liberal thought and has been instrumental in stymying the environmental movement's progress. Moreover, the neo-liberal Julian Simon developed a powerful critique of environmentalism in the 1980s, which Daly has not responded to. Over the last half-century, neo-liberal environmental thought has cast a shadow over ecological economics, even though Daly seems unable to perceive its influence on his life's work. If the environmental movement wants to win the fight, then it needs an entirely new ecological economics.

When the US environmental movement came of age in the 1960s and 1970s, activism in the streets was accompanied by scholars undertaking the long march through university departments. To cite but a few examples, environmental history became a fast growing sub-field, while the dismal science expanded to include a branch for ecological economics. By and large, academic environmentalism assumed the ideological posture of the movement that birthed it, and sought to safeguard its respectability, was uninterested in broader radical politics and oblivious to its manipulation by neo-liberals (Gottlieb, 1993; Dowie, 1995). While environmental historians have secured an ample swathe of territory within their discipline, history as a whole has suffered with the steep decline in student enrolment in many universities over the past generation. Economics may have been one of the few disciplines to flourish in higher-education's contemporary age of austerity, but ecological economists cling to a toehold within a discipline that has become hostile to their efforts. Thus, the gains from half a century of environmental scholarship has been less than one might have expected. However, this shortcoming can be traced

to its inherent conservatism. The Right may think that environmentalists are watermelons – green on the outside and red on the inside – but the truth is they too often are pears, and white, after all, is the colour of reaction.

This article will focus on the fortunes of ecological economics through the works of Herman Daly, the field's best-known practitioner. Daly did not found ecological economics, whose roots can be traced back to the 1950s or even the 1910s, but he has greatly influenced how it is presently configured. More than anyone else he is responsible for the elevation of the 'steady-state' economy as an object of study. Appropriate for the genre of biography, Daly is not only an influential historical figure, but in many ways representative of his caste. A Texan born in 1938, Daly studied at Vanderbilt University under the tutelage of Nicholas Georgescu-Roegen, who perhaps is best known today for the classic in ecological economics, *The Entropy Law and the Economic Process* (1971). Georgescu-Roegen, like other members of the first generation of ecological economists that included Ezra Mishan (1967), Kenneth Boulding (1966) and Ronald Coase (1960), could succeed in the mainstream of neo-classical scholarship while dabbling in a

Troy Vettese

About the author

Troy is a postdoctoral fellow in Canadian Studies at the Weatherhead Center, Harvard University, Cambridge, MA, USA.

Citation

Vettese T (2020) Against steady-state economics. *The Ecological Citizen* 3(Suppl B): 35–46.

Keywords

Eco-socialism; ecological economics; neo-liberalism; overpopulation; sustainability

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new sub-field. In contrast, their students specialized in environmental questions and for their efforts often found themselves barred from the top tier of the discipline. Daly taught for decades at Louisiana State University and the University of Maryland, and also put in a six-year stint at the World Bank. His influence amongst activists and scholars in the humanities has proven greater than amongst fellow economists.

In addition to increasing environmental concerns, another trend in economics during the 1960s was the discipline's creeping neo-liberalization (Mirowski, 2006). The mainstream was dominated by neo-classical economics, the nineteenth-century school based on marginalism and general equilibrium analysis. Neo-liberalism, appearing two generations later in the inter-war period, drew upon an entirely different set of principles devised by Frank Knight, Friedrich Hayek and Ludwig von Mises. Philip Mirowski (2013) argues that neo-liberalism is best understood as an ideology predicated on the belief that the market is less a site of exchange than an omniscient information-processor. Thus, if the market can accumulate and process information faster than any other institution – especially central planning – then *all* institutions should be reorganized on a market basis. Although not a neo-liberal himself, Daly seems to underestimate the influence of neo-liberalism on his work, an omission that has dulled his critical edge and undermined the field of ecological economics more broadly.

It is Daly's relationship to neo-liberalism that will serve as the analytical axis of this article. Notably, one of Daly's first articles, “On Economics as a Life Science” (1968), was published in the Chicago School's house periodical, the *Journal of Political Economy*. That article spelt out many of the principles of steady-state economics that he would continue to develop for the rest of his career. This includes a faith in markets, neo-liberal regulatory tools and theory, and Malthusianism. While Daly criticises economic growth, he believes that capitalism – history's most dynamic social system – can be restrained within a

steady-state by a flimsy mesh of regulation. Cap-and-trade is his main regulatory tool to achieve a steady-state, even though it emerged from neo-liberal thought and has been instrumental in stymying the environmental movement's progress (Mirowski, 2013). Moreover, the neo-liberal Julian Simon developed a powerful critique of Malthusianism in the 1980s, which Daly ignored. Thus, neo-liberal environmental thought has long cast its shadow over the field of ecological economics.

Why is there economic growth?

Ecological economists tend to believe that the environmental crisis is a matter of misunderstanding, and one only needs to convince people of the foolishness of economic growth. Daly often speaks of economic growth as an ‘addiction’, ‘ideology’ or ‘obsession’. Such language is typical for the field, which can be found in works by Tim Jackson (2009), Robert Costanza and co-authors (2016), and most recently, Giorgos Kallis (2019). Ecological economists endow the concept of GDP with talismanic properties, for they believe that it does not simply measure economic growth but also produces that effect. This is why Daly and his peers busy themselves to replace GDP with alternative measurements that include environmental factors (e.g. Lawn and Sanders, 1999).

The idea that economic growth is a process driven by beliefs rather than economic structures comes from the environmental movement itself. While remaining critical of developments that threatened prized natural areas, most environmentalists have shied from any rigorous theorizing about capitalism itself for that would risk seeming Marxist. The result is the vague, anti-business sentiment that pervades the movement, which is epitomized by John Muir (1908) blaming the “devotees of ravaging commercialism” for the destruction of the Hetch Hetchy Valley, and Gary Snyder's denunciation of the “secret heart of this Growth-Monster” (1990). The theoretical lacuna where capitalism should be has weakened the praxis of environmental activists and

scholarship by environmental academics. GDP, after all, is a rather new measure, only emerging in its present recognisable form in the 1940s, though efforts aimed at national accounting date back to the 1920s (Tooze, 2001; Schmelzer, 2016). Sustained economic growth, however, predates GDP by centuries, so how did capitalism ravage environments long before anyone bothered to track its progress? To understand why sustained economic growth exists at all, one has to delve deeply into the structures of capitalism itself.

Few have done this better than Ellen Meiksins Wood, a Marxist historian. In her seminal study, *The Origin of Capitalism* (2002), she defined capitalism as a system marked by the compulsion – not merely the opportunity – to participate in markets. While markets have long existed, capitalism is relatively new because it represented a system where people depended on markets completely, which set into motion the requirement to constantly increase labour productivity. “Material life and social reproduction in capitalism are universally mediated by the market,” she explains, “so that all individuals must in one way or another enter into market relations in order to gain access to the means of life” (Wood, 2002: 7). This situation unconsciously emerged in medieval England, as lords lost their rights to directly control peasants and therefore could only access land and labour through the market. This set in train a competitive dynamic where lords were forced to increase the productivity of their tenants through agricultural ‘improvement’. Even if they owned the land themselves, they could only maintain their class position by producing and selling at the going rate, otherwise they would eventually be ejected out of the dominant class. Notably, Wood stresses that labour productivity was often increased in energy-intensive and environmentally deleterious ways, a dynamic that elucidates the relationship between capitalism, economic growth and environmental degradation. Focussing on economic growth rather than the class relations that produce it ironically leads ecological economists to fetishize

GDP and overlook the factors that better explain this process.

There is a strange overlap between Marxists and neo-liberals in their disregard for GDP. Neo-liberals would agree with Marxists that the most important heuristic of economic analysis is profit rather than economic growth *per se*. This contrasts with neo-classicists who have long been interested in national income accounting. This divergence between neo-liberals and neo-classicists can be traced back to the break between the two traditions. In the 1920s Hayek ran the Austrian Institute for Economic Research (*Österreichischen Institut für Konjunkturforschung*), an outfit set up by Mises to supply clients with insights into the business cycle. Quinn Slobodian (2018) has recently shown that these early neo-liberals dreaded the possibility that attempts to comprehend the economy as a whole would give socialists the confidence to plan it. In short, familiarity could breed contempt of the economy, engendering the aspiration that one could transcend the market through central planning.

As a response, Hayek transformed himself in the early 1930s from market expert to mystic, declaring the market to be an unknowable entity (1933; 1937; 1945). This was, he argued, because the knowledge that was dispersed amongst millions of individuals could be concentrated through the prism of the price system. The diffusion of knowledge meant that no single individual or institution could consciously replicate the efficiency of distribution unconsciously achieved by the market. Attempts to encapsulate the market’s workings using neo-classical techniques of equilibrium analysis – let alone central planning – were doomed. If a firm could not know its own supply curve at any given time how could an economist know how the economy as a whole functioned? Marxists and neo-liberals would agree that it is profit rather than growth that is the metric that actually matters for capitalism, leaving growth as a mere byproduct of a different social logic.

Using Wood’s framework, one can see that the only way to stop the drive for endless economic growth is to undo the necessity

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to participate in markets. That is, the conscious political control over production and distribution through central planning is the only way to stop and reverse capitalism’s ceaseless incorporation of the natural world. Daly, however, believes that a steady-state economy could be realized within capitalism. “I wouldn’t really take the view,” he remarked recently to Benjamin Kunkel in the *New Left Review*, “that we should just abandon capitalism and opt for eco-socialism” (Daly, 2018: 96). His preferred model would be “Jeffersonian-type, small-scale capitalism, operating within scale and distributive limits” (Daly, 2018: 96). Yet, the centrality of profit means that it is impossible to imagine any capitalist calmly accepting the strictures that the ecological economists would impose on a steady-state economy.

Capitalists would fight to remove any restrictions on economic growth not because of any ‘growthmania’ but because they fear falling behind competing national capitals, leaving them vulnerable to rout on the market, not to mention losing their class position in a socialist society. An inevitable revolt of the elites against the steady state would not be dissimilar from what happened in Chile in 1973. In the aftermath of that *coup d’état*, Ralph Miliband (1973) condemned the “Wise Men of the Left” who “have hastened to proclaim that Chile is not France, or Italy, or Britain” and harbour the delusion that a bloody reaction to socialism is impossible in the Global North. Environmentalists should heed Miliband’s advice to create movements “able and willing to engender and encourage the effective, meaning the organized, mobilization of popular forces.” Otherwise, they “may well be preparing new Chiles for themselves.”

Neo-liberal nostrums

Ecological economists have escaped a Santiago-style bloodbath because their tools, especially cap-and-trade, do not work. Daly lauds cap-and-trade as “the policy most in accord with maintaining natural capital” (2005: 103–4) and because it is supposedly more efficient as it uses

the market rather than central planning to achieve its aims. In this it can be seen how, although not a card-carrying neo-liberal, Daly ascribes to many precepts of that movement. For him, markets are sites to “exchange information” and he is critical of “direct allocation through central planning” (Daly, 2018: 96). As he told Kunkel, “if you try to get rid of markets, you’re really creating a problem” (Daly, 2018: 97).

What is cap-and-trade? The government sets a limit on the use of a certain resource and creates fungible tranches of that use-right, which can then be auctioned off to firms to create a price. Confusingly, Daly sometimes refers to ‘depletion quota auctions’, a term he uses to signify cap-and-trade programmes that regulate industrial inputs (e.g. coal or petroleum), and he reserves the term ‘cap-and-trade’ for outputs (e.g. carbon dioxide), but they operate on the same principles.

Cap-and-trade is the alternative to prohibition and best-available-technology regulation to reduce pollution, techniques derided by neo-liberals as ‘command and control’. Cap-and-trade was in fact developed as the neo-liberal alternative to another regulatory possibility that Daly does not consider: the neo-classical solution of taxing negative externalities. The latter was first formulated by Arthur Pigou in his *The Economics of Welfare* for instances where “external economies” created a “divergence between social and trade [sc. private] net product” (1920: 159). That is, externalities occur when non-participants in production are rendered “services or disservices,” but “technical considerations prevent payment being exacted from the benefited parties or compensation being enforced on behalf of the injured parties.” Pigou’s solution was to tax unpaid costs, returning the market to equilibrium. In the case of positive externalities (e.g. pollination services given by a beekeeper), subsidies should be given to compensate the providers of such services so that they are produced at an efficient level (Meade, 1952).

Neo-liberals, however, fumed against the Pigovian concept of externality for the

same reason that they are wary of GDP: it is based on the assumption that the economy is knowable and that a planner (rather than the market) can accurately assess economic value. They countered that no civil servant could accurately estimate the cost of an externality because only prices that emerge from the market have any validity. The problem was thus how to create a market in environmental problems. Eventually John Dales of the University of Toronto provided a solution in his *Pollution, Property and Prices* (1968), where he outlined the cap-and-trade framework. In the 1980s and 1990s cap-and-trade programmes were implemented in a few jurisdictions, especially in fisheries and air pollution, but the deluge in market-based environmental regulation did not come about until the 2000s, after the US government inserted cap-and-trade into the heart of the Kyoto Protocol. The US had to overcome tough European resistance to this globalization of cap-and-trade because the latter had championed Pigovian taxation (Voß, 2007).

Yet, the track record for cap-and-trade programmes has been terrible. The largest and most important carbon market, the EU Emissions Trading System (ETS), produces enduringly low prices for carbon. “Money that might have been used productively to alter the energy infrastructure instead gets pumped into yet another set of speculative financial instruments,” Mirowski laments, “leading to bubbles, distortions of capital flows, and all the usual symptoms of financialization” (2013: 339–40). At its nadir in 2013, carbon fetched €3 per ton and even now at the moment of writing in October 2019 the price is only €22 per ton. This is a far cry from an effective price for carbon. ExxonMobil, for example, estimates it would need to be US\$2000 per ton for global warming to be limited to 1.6°C (Eaton and Carroll, 2015), which is in line with the Intergovernmental Panel on Climate Change’s estimates (2018). The EU ETS was doomed from the beginning, as, in order to placate industry, too many permits and offsets were issued. As Raphael Calel (2013: 112) observes:

In 2006 it became apparent that there was a surplus of allowances and their price collapsed [...] Phase 1 emissions are estimated to have been only about 3% lower than they would have been without the EU ETS [...] When EU ETS installations are instead compared directly to similar installations that were not covered by the EU ETS, although this has so far only been done for a very limited number of installations, even the modest 3% reduction vanishes.

Other markets, like the Chicago Climate Exchange and California’s carbon market, have also experienced spectacular crashes and, in general, have proven useless in reining in emissions (Drury *et al.*, 1999; Cullenward, 2014). Many of the gains that have been achieved by cap-and-trade programmes, like the much vaunted Clean Air Act Amendments of 1990, upon closer inspection turn out to be due to residual technical standards and Pigovian regulation. “It is worth noting,” Calel remarks, “that Title IV of the Clean Air Act, which establishes the Acid Rain Program, also includes special provisions that reward firms specifically for the use of scrubbers, so it is not entirely clear how much of this was the market’s doing” (2013: 115). Similarly, cap-and-trade programmes in fisheries have rarely restored fish stocks (Acheson *et al.*, 2015). Instead they have allowed environmentally deleterious practices to continue or concentrated ownership in a few hands by expelling poor fishers into unemployment.

Mirowski argues that the recurrent failures of cap-and-trade programmes are intentional rather the result of sincere incompetence. In the case of carbon markets, he suggests that many neo-liberals are too smart to believe in climate-denial, but find it useful to buy time in the short-term. In the medium-term, (after climate-deniers are defeated) then cap-and-trade programmes can be set up but prices are rigged to stay low to avoid economic disruption. Moderate environmentalists, economists and incumbent firms will then fight to preserve cap-and-trade regulation, tying up political capital that could have

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gone into effective climate action. This buys yet more time for entrepreneurs to perfect forms of geo-engineering like ‘solar radiation management’, which represent the neo-liberals’ permanent solution to climate change. If Mirowski is correct, then well-intentioned supporters of cap-and-trade like Daly have been conscripted unawares by neo-liberals. The true solutions to environmental problems like climate change are what neo-liberals dread: prohibition and central planning, even though ecological economists have come to abhor such measures.

A truly effective cap-and-trade programme would put a damper on economic growth. The originator of cap-and-trade, Dales, was quite aware of this when he first began propounding his idea in the 1960s. As he told a reporter from the *Toronto Telegram*, “I would want taxes to go up. If we want cleaner air and water, we have to give up something to get it” (*Telegram*, 1968). While neo-liberals may appreciate the elegance of his solution, they were less keen on putting a straitjacket on the economy. Not for the first time, cap-and-trade shows that neo-liberalism may be an ideology that works in theory, but fails in practice. Sensitive as they are to the capitalist’s need to match the going rate of profit, neo-liberals strive to regulate with a light touch even if it they have to sabotage their own market-fixes. Daly, however, should not be condemned simply because he borrows from neo-liberalism, for one can always be inspired by hostile intellectual currents. After all, the neo-liberals have frequently borrowed from Marxists. However, intellectual translations should always be carried out with a consciousness of the context in which those ideas emerged, and those ideas put to use in a way that prevents the replication of hostile assumptions.

Malthusians and neo-liberals

If Daly’s employment of neo-liberal concepts was neither overt nor reflective, Malthusianism has always been integral to his *Weltanschauung*. In this regard, he was typical of his generation, for the

English parson’s bleak political economy became massively popular in the post-war era. Malthusianism offered intellectuals a discourse to link their despair over nature’s plight to their latent dread of decolonization. Yet, it was biologists rather than economists like Daly who spearheaded the revival of Malthusianism. Early landmarks included Fairfield Osborn’s *Our Plundered Planet* (1948) and William Vogt’s *Road to Survival* (1948). Its breakthrough properly arrived a generation later in the late 1960s and early 1970s, when the Keynesian order was creaking under the strains of the Vietnam War and a myriad of environmental crises.

No one represented the Malthusian avant-garde better than the entomologist Paul Ehrlich. He became a convert to the cause after a trip to India in 1966. As he later recollected, “the streets seemed alive with people. People eating, people watching, people sleeping. People visiting, arguing, and screaming. People thrusting their hands through the taxi window, begging. People defecating and urinating. People clinging to buses. People herding animals. People, people, people, people” (Ehrlich, 1968: 1). Upon his return to the US he lectured widely on overpopulation. David Brower, the dynamic leader of the Sierra Club, attended one of these presentations and was so impressed that he induced Ehrlich to write a book. This became *The Population Bomb* (1968), a book that famously began with the prophecy that “in the 1970s and 1980s hundreds of millions of people will starve to death in spite of any crash programs embarked upon now” (1968: xi). To mitigate the worst, Ehrlich countenanced “compulsion” if voluntary measures failed to control population growth (1968: xii).

Daly too speaks of population growth as the gravest of all environmental problems. His interest in demographics sprang from a Ford Foundation fellowship in Brazil’s *Nordeste* early on in his career. During a student strike at his host institution, the Federal University of Ceara, Daly read up on overpopulation and environmentalism. As he later reflected, “In my mind, these

three things – Georgescu[-Roegen]’s understanding of entropy and economics, Brazilian society and [Rachel] Carson’s ecology – started to cohere” (2018: 85). This intellectual chemistry led to his 1968 article in the *Journal of Political Economy* and the future trajectory of his life’s work. In 1970, he argued that development economics required a ‘change of emphasis’ that elevated population policy (1970: 537). He referred to the growing population of the Nordeste as “this swelling” that was building up to “an ecological explosion” (1970: 539). Economists needed tools to control demography so they could treat it as another “variable in the development effort,” rather than as a “semisacred [sic] constant of nature” (1970: 539). He thought the contemporary Left had little to offer, decrying how “collectivists are more interested in the total, and one more individual usually adds to total power, in the sense of increasing the herd” (1970: 559).

To address overpopulation, Daly turned to the trusty instrument of cap-and-trade. The state would give women birth-licences, which they could sell or give to others (Daly, 1974: 19). He credits Kenneth Boulding for the idea, but Boulding claimed to have made the suggestion in jest. Daly, however, was serious then and even now approves of coercion if it is necessary to achieve global population control (Daly, 2018). One only hopes that if such a regimen were ever implemented, it would be as ineffective as cap-and-trade has proven to be for carbon emissions. Counterfeit offsets would be preferable to forced abortions.

In the 1980s the neo-liberals began their offensive against Malthusians like Ehrlich, for the two ideologies were incompatible. This was not because of any aversion to violence, as the neo-liberal support for the Pinochet government made clear. Rather, they opposed the Malthusians’ implication that natural scarcity represented a market failure that could only be solved via violence. The neo-liberals’ champion in this fight was Julian Simon, an obscure business professor at the University of Illinois. In the pages of *Social Science Quarterly* in 1980 and

1981, Ehrlich and Simon traded barbs and eventually made a wager concerning the price changes of five commodities over ten years. Ehrlich bet that scarcity would drive up prices, while Simon believed the price-system would signal to entrepreneurs to invest in sectors before scarcity became a true constraint, thus keeping prices low. In the fall of 1990, it was clear that Simon won, as the prices for copper, chrome, nickel, tin and tungsten had tumbled by nearly half. The Malthusian wave thus crested and receded, while neo-liberals were at the cusp of their golden age.

It is worth elucidating Simon’s framework because it arrested the Malthusians’ seemingly ineluctable advance. He created a new branch of neo-liberal environmental thought that would be taken up by others such as Bjørn Lomborg (1998), Stephen Moore (with White, 2016) and countless epigones. Moreover, if one reads Daly’s works in the period since this debate it appears that he and the broader community of ecological economists have not learnt their lesson from this defeat. There are three main components to what one can call ‘neo-liberal cornucopianism’: the distinction between a *resource service* and a *physical resource*; human capital as the ‘ultimate resource’; and energy as the ‘master resource’ that allows the transmutation of one resource into another.

In 1980, Simon published a short essay in *Science* that outlined his programme of cornucopianism. To redefine ‘resources’ to exclude concerns of scarcity, he argued that “as consumers we are interested in the services we get from the raw materials rather than the raw materials themselves” (1980: 1435). He gave the example of a copper pot: what interests consumers is less the copper itself, but rather “a container which can be put over heat,” and therefore “the cost that interests us is the cost of providing the cooking service, rather than the cost of copper” (1980: 1435). It was the price of these services that represented scarcity, not the absolute amount of a natural resource, so as long as the price for such services continued to fall then there was no crisis.

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Simon expanded these arguments the following year in his magnum opus, *The Ultimate Resource* (1981). While Ehrlich and other Malthusians argued that population growth increased pressures on natural resources, Simon counter-intuitively argued that a larger population has historically led to lower costs for natural resources. This is because the ‘ultimate resource’ was humanity itself and thus more humans quite literally meant more human capital. “From the economic point of view an additional child is like a laying chicken, a cacao tree, a computer factory, or a new house [...] additional persons produce more than they consume in the long run, and natural resources are not an exception” (Simon, 1981: 4). More human capital meant improvements in extracting and transporting resources, leading to lower resource costs over the long-run even after high-quality lodes were depleted. For this reason, Simon contested the distinction geologists made between ‘reserves’ and ‘resources’; that is, between economic and non-economic deposits. He was especially interested in non-conventional fossil fuels for this reason and criticized the US Geological Survey for its overly ‘sensitive’ definitions of petroleum. “If one also includes oil that can be forced to the surface under pressure [enhanced oil recovery, EOR], plus naturally non-liquid oil in shale and tar sands and other sources, the estimate would be considerably greater” (1981: 106). Once the boundary between reserves and resources is thus collapsed, nature’s bounty appeared limitless.

If human capital was the ‘ultimate resource’, Simon reasoned, then energy was the ‘master resource’ for it “enables us to convert one material into another” (1981: 91). Following this insight, he leapt to its logical terminus that capitalism would lead to the complete abstraction of nature. “We and our descendants can manipulate the elements in such fashion that we can have all the raw materials that we desire at prices ever smaller relative to other goods and to our total incomes” (Simon, 1998: 67). Thus, there was no point in speaking of nature as an array of particular physical things.

Instead, all that existed were ‘elements’ that could be recombined given the dictates of the market. In the future everything would be synthetic, as the initial endowment of nature would be integrated, transformed and destroyed by commodification, creating a new second nature. The future era of molecular capitalism would be predicated on ever greater consumption of energy. “As natural scientists continue to learn more about the transformation of materials from one form to another with the aid of energy, then energy will be even more important” (Simon, 1981: 91). All of this required energy prices to remain low because “if the cost of usable energy is low enough, all other important resources can be made plentiful” (Simon, 1981: 91). Simon did not put his faith in cheap renewables or a *deus ex machina* like cold fusion but in limitless non-conventional fossil fuels. This cornucopianism helps to explain why neo-liberals have been so loath to abandon fossil fuels, and why they would eventually put their faith in geo-engineering to ensure an endless horizon for hydrocarbons.

Of course, Malthusians did not leave Simon’s arguments uncontested. Ehrlich with his co-authors responded to Simon’s initial 1980 article in *Science*, and they were especially flabbergasted by his argument for modern alchemy. Simon’s comment that “copper can be made from other metals” was met by howls of derision. “Indeed! Perhaps Simon here has in mind the technique of elemental transformation by bombardment with subatomic particles in accelerators,” sneered Ehrlich, his wife Anne and their protégé John Holdren. “Producing microgram quantities of copper by this means would be a gargantuan feat. Any implication that production in industrial quantities might be economically or energetically feasible is preposterous” (Holdren *et al.*, 1980: 1298–9). Simon’s arguments may have been crude, but they had greater efficacy than the Ehrlichs and Holdren ascribed to them. Making copper from scratch may be difficult, but turning bitumen into petroleum was feasible and this process engendered an entirely new branch of the non-conventional

hydrocarbon industry to emerge in the north-west reaches of the Canadian boreal forest.

Another example from their debate over scarcity concerned the global fishing industry. In an exchange between Paul Ehrlich and Simon in 1981 in *Social Science Quarterly*, they discussed recent trends in fish landings. Ehrlich argued (1981) that fish stocks were declining, while Simon disagreed (1982). It turned out that Ehrlich was right, and that world fish stocks were on the cusp of numerous collapses, none more ominous than the destruction of what had seemed to be the limitless cod fishery of the Grand Banks. However, making a Simonian argument that he himself did not make at the time, one could counter that it is the service from fish that matters – that is, fish flesh – not the particular pelagic fish themselves. Thus, fish stocks could collapse, but as long as substitutes from aquaculture took their place and prices for meat remained low, then there was no crisis. Thus, even though Ehrlich and fellow Malthusians have been correct in many of their predictions, they lost the argument to the neo-liberals in a practical sense. If society appraises nature via the market, then too often the destruction of rare minerals or animals leave barely a wrinkle in prices as substitutes take their place (Hanner, 1981).

Although Daly and Ehrlich have collaborated together and indeed work towards many of the same goals, Daly seems not to have registered the damage wrought to ecological economics by the neo-liberal critique. Without mentioning Simon directly, Daly argues against the possibility of limitless substitution. “The complementary nature of natural and human-made capital is made obvious,” he insists, “by asking what good a saw mill is without a forest; a refinery without petroleum deposits; a fishing boat without populations of fish” (Daly, 2006: 31). The argument that human-made capital cannot complement the deteriorated stock of natural capital is an argument against the feasibility of endless growth. If too many fish are caught, then the “capital of

fishing boats and canneries will also be diminished in value” (Daly, 2006: 37). In another example, he presents the limits of substitution as the impossibility of building “the same wooden house with half the timber no matter how many saws and carpenters one tries to substitute” (1995: 51).

This, however, is not how Simon describes substitution. Rather, more scientific, technical and mechanical capital is invested to develop inferior but larger stocks of *natural* capital, be it deep-sea dwellers that are caught and fed to farmed fish, or building upgraders to synthesize bitumen from the Canadian tar sands. No can say how long this process of substitution can go on for, but hard limits to capitalist expansion do not seem to be in the offing any time soon. Moreover, as early as the 1970s neo-liberals recognized that conserving a natural resource to maintain a sustainable harvest (as Daly advocates) makes little economic sense. Instead, one needs to compare the discount rate with the reproduction rate. For example, if one could invest and get a return of ten per cent a year, then it makes economic sense to run down an asset (e.g. whales) if the reproductive rate is only five per cent. That is, economic rationality would suggest that one is better off killing all the whales quickly, and then investing the profits elsewhere (Clark, 1973).

The limits of ecological economics

Despite Daly’s seemingly limitless ability to publish, the contours of a steady-state society have remained vague. He often uses the metaphor of the Plimsoll line of a ship, suggesting that if neo-classical economics concerns the efficient distribution of goods on a ship, then ecological economics provides insight into its carrying capacity (Daly, 1991). Yet, how this latter figure is determined is never elucidated in his oeuvre. He gives a few potential ways to argue that growth is impossible, but those are not solutions to this problem. For example, a corollary of his views about substitution was that eventually it would lead to ‘uneconomic growth’ from having

“If society appraises nature via the market, then too often the destruction of rare minerals or animals leave barely a wrinkle in prices as substitutes take their place.”

too much human-made capital instead of the natural kind. Yet, this ignores the structural imperative for capitalists to pursue profits despite any costs they might impose on others.

Another potential basis Daly uses to forecast the limits of growth is the 'human appropriation of the total world products of photosynthesis' or Net Primary Production (NPP). Peter Vitousek and his co-authors (1986) devised this measure to convey how much of the natural world is controlled by humans and redirected to their ends. They estimated that the global total of NPP was 25%, but that figure rose to 40% if one looked only at terrestrial life. Daly reasoned that "more than two doublings exceeds 100 per cent [...] the terrestrial figure of 40 per cent is probably more relevant since we are unlikely to substantially increase our take from the oceans," and therefore 'the human scale' could only slightly more than double before taking all NPP (1990: 30). Although he recognized that the total appropriation of NPP was an "ecological impossibility," how much NPP could grow was left unanswered. However, waiting for capital to attempt to subsume all of the Earth's photosynthetic resources is obviously not a good strategy for environmentalists.

Daly argues for a maintenance of the economy's current proportions, what he calls the 'steady state', but it is not clear why this is necessarily ideal. Georgescu-Roegen criticized his student's work on this basis, arguing that according to the logic of the entropy law a steady-state would be impossible to maintain. As non-renewable resources were used up, the economy would contract and eventually cease. Daly's "vision of a blissful world in which both population and capital stock remain constant" was, for Georgescu-Roegen, a "myth of ecological salvation." The "various logical and factual snags" of Daly's vision lay in "some confusion between finite stock and finite flow rate" (Georgescu-Roegen, 1975: 367).

Shrinking the scope of some national economies could be justified on grounds that Daly does not consider. For example, if renewable energy systems were

implemented they would take up vast amounts of space due to their low power density (Smil, 2015), and therefore total energy production should decrease. Instead of NPP, Daly could instead consider how much land is necessary to prevent mass extinctions. Plants and animals need wild habitat to survive, and it is remarkably simple to determine the relationship between land and biodiversity. The entomologist EO Wilson (2016) has, for example, called for half the Earth to be protected for other species, which is over three times the amount of protected land that exists today. The land problem presented by renewable energy and the sixth mass extinction provides a useful heuristic for economic policy, but it is never discussed by Daly. This might be because Daly, a guilty-minded omnivore, assumes only humans are capable of consciousness (Daly, 1987; 2018).

Younger generations of ecological economists now should grapple with the questions that have been ignored by Daly. How can the limits of the steady-state be imposed on recalcitrant capitalists? On what basis should one decide the size and scope of a steady-state economy? Is it wise to rely on neo-liberal assumptions like cap-and-trade? What is their response to Simon's critique of Malthusianism? Why do ecological economists continue to embrace Malthusianism despite its latent racism and sexism?

To remedy these problems, ecological economists will first have to take a hard look at neo-liberalism and capitalism to reduce their vulnerability to being co-opted, and to discern the obstacles that prevent the implementation of a radical environmental programme. Moreover, ecological economists must spurn the lure of Malthusianism both on intellectual and political grounds, to build a coalition with a broad Left that supports self-determination and feminism. Ecological economists could do more to cooperate with the more radical factions of the environmental movement that have fought for environmental justice. If the environmental movement wants to win, it will have to be led by workers, radical

“Ecological economists have to take a hard look at neo-liberalism and capitalism to reduce their vulnerability to being co-opted, and to discern the obstacles that prevent the implementation of a radical environmental programme.”

intellectuals, animal-rights activists, environmental justice campaigners and the non-white people whose bodies the Malthusians have sought to control. If the environmentalist movement is remade in this way, then an entirely new ecological economics will be needed too. ■

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